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Preface

The science of nanomaterials has become the flavour of the day, with research being driven both by academic curiosity and the promise of useful applications. Amongst the nanomaterials, nanocrystals, nanowires and nanotubes constitute three major categories, the last two being one-dimensional. Since the discovery of the carbon nanotubes in 1991, interest in one-dimensional nanomaterials has grown remarkably, and a phenomenal number of research articles has been published on nanotubes as well as nanowires. The nanotubes are not only those of carbon but also of inorganic materials. Several strategies have been developed for the synthesis of these materials and a range of interesting properties reported. Thus, the electronic and mechanical properties of carbon nanotubes have been studied extensively, and several of them directly relate to potential applications. Typical of the important properties of carbon nanotubes are high mechanical strength, good electrical and thermal conductivity and excellent electron emission characteristics. The electronic and Raman spectra of carbon nanotubes have helped immensely in characterization as well as in understanding some of the intrinsic structural characteristics.

While nanotubes of several inorganic materials, many of which possess layered structures, have been synthesized and characterized, the literature on inorganic nanowires is much more extensive. Every conceivable inorganic material seems to have been prepared in nanowire form. Properties and possible applications of these inorganic one-dimensional materials have been investigated to some extent, but there seems to be ample scope for study.

This monograph provides an up-to-date survey of various aspects of carbon nanotubes, inorganic nanotubes and nanowires. Nanotubes of lipids, peptides, polymers and DNA are known, but they have not been discussed in this monograph due to its limited scope. We have found it difficult to cover the entire gamut of properties and applications of the nanotubes and nanowires in detail in view of the immense literature that has accumulated in the last three to four years. We have been selective, emphasizing more the chemical aspects of nanotubes and nanowires, especially those related to synthesis and characterization to a greater extent. We have provided an extensive list of references to enable those who would like more complete information on the properties and other aspects of these

materials. It is possible that we have failed to cite some important references by oversight or error in judgement, and we would like to be excused for such omissions. We have done our best to make the monograph contemporary and we hope that students, teachers and practitioners of nanoscience will find it useful.

C.N.R. Rao
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C.N.R. Rao obtained his PhD degree from Purdue University and DSc degree from the University of Mysore. He is the Linus Pauling Research Professor and Honorary President of the Jawaharlal Nehru Centre for Advanced Scientific Research and Honorary Professor at the Indian Institute of Science (both at Bangalore). His research interests are mainly in the chemistry of materials (e.g., transition-metal oxides, open-framework structures, and nanomaterials). He has authored nearly 1000 research papers and edited or written 30 books in materials chemistry. A member of several academies including the Royal Society, US National Academy of Sciences, Japan Academy, French Academy of Sciences, and the Pontifical Academy of Sciences, he is also Distinguished Visiting Professor at the University of California, Santa Barbara. He was awarded the Einstein Gold Medal by UNESCO, the Hughes Medal by the Royal Society, and the Somiya Award of the International Union of Materials Research Societies (IUMRS). In 2005, he received the Dan David Prize for materials research from Israel and is the first recipient of the India Science Prize.

A. Govindaraj obtained his M.Sc and Ph.D degrees from the University of Mysore. His main research interests are in fullerenes, nanowires and nanotubes in which areas he has published extensively. He is a Senior Scientific Officer at the Indian Institute of Science and Honorary Faculty Fellow at the Jawaharlal Nehru Centre for Advanced Scientific Research.

Contents

Abbreviations xi

Chapter 1 Carbon Nanotubes 1

1 Introduction 1
2 Synthesis 3
Multi-walled Nanotube 3
Aligned Nanotube Bundles and Micropatterning 8
Single-walled Nanotubes 16
Peapods and Double-walled Nanotubes 25
Mechanism of Formation 26
Purification and Separation 29
3 Structure, Spectra and Characterization 33
General Structural Features 33
Raman and Other Spectroscopies 37
Pressure-induced Transformations 41
Electronic Structure 44
4 Chemically Modified Nanotubes 48
Doping with Boron and Nitrogen 48
Intercalation by Alkali Metals 50
Opening and Filling of Nanotubes 51
Reactivity, Solubilization and Functionalization 53
5 Electronic Properties 61
6 Carbon Nanotube Composites and their Properties 66
7 Applications, Potential and Otherwise 73
Electronic Applications 74
Field-effect Transistors and Related Devices 77
Field Emission 79
Supercapacitors and Actuators 83
Sensors and Probes 84
Lithium Batteries 88

Gas Adsorption and Hydrogen Storage 88
Other Useful Properties 91
References 91

Chapter 2 Inorganic Nanotubes

1 Introduction 111
2 Synthetic Methods 114
3 Specific Cases 116
4 Properties 122
Mechanical Properties 122
Electronic, Magnetic, Optical and Related Properties 124
Tribological Properties 126
Chemical Modifications and Applications 127
References 129

Chapter 3 Inorganic Nanowires

1 Introduction 135
2 Synthetic Strategies 135
Vapour Phase Growth 136
Solution-based Growth of Nanowires 140
Growth Control and Integration 143
3 Elemental Nanowires 144
Silicon 144
Germanium 150
Boron 152
In, Sn, Pb, Sb and Bi 154
Se and Te 155
Gold 157
Silver 161
Iron and Cobalt 164
Nickel and Copper 166
Other Metals and Alloys 168
4 Metal Oxide Nanowires 172
MgO 172
Al_2O_3, Ga_2O_3 and In_2O_3 176
SnO_2 183
SiO_2 and GeO_2 186
TiO_2 191
MnO_2 and Mn_3O_4 193
Cu_xO 194
ZnO 196
Vanadium and Tungsten Oxides 200
Other Binary Oxides 201
Ternary and Quarternary Oxides 203

5 Metal Nitride Nanowires 206
BN 206
AlN 209
GaN 210
InN 217
Si_3N_4 and Si_2N_2O 221
6 Metal Carbide Nanowires 221
BC 221
SiC 223
7 Metal Chalcogenide Nanowires 226
CdS 226
CdSe and CdTe 228
PbS and PbSe 229
Bismuth Chalcogenides 229
CuS and CuSe 230
ZnS and ZnSe 231
NbS_2 and $NbSe_2$ 234
Other Chalcogenides 235
8 GaAS, InP and Other Semiconductor Nanowires 236
GaAs 236
InP and GaP 237
9 Miscellaneous Nanowires 239
10 Useful Properties and Potential Applications 241
References 242

Subject Index 265

Abbreviations

AAM	Anodic Alumina Membrane
AFM	Atomic Force Microscope (Microscopy)
BNNTs	Boron Nitride Nanotubes
c.m.c.	Critical Micelle Concentration
μCP	Microcontact Printing
CNTs (or CN)	Carbon Nanotubes
CSR	Carrot-shaped Rods
CTAB	Cetyltrimethylammonium Bromide
CVD	Chemical Vapour Deposition
DOS	Density of States
DWNTs	Double-walled Carbon Nanotubes
EDX	Energy Dispersive X-ray Spectroscopy
FE	Field Emission
FEED	Field-emitted Electron Energy Distribution
FET	Field-effect Transistor
F-N	Fowler–Nordheim (plot)
F-SWNTs	Fluorinated Single-wall Nanotubes
HFCVD	Hot-filament Chemical Vapour Deposition
HiPco	High-pressure CO Disproportionation Process
HOPG	Highly Oriented Pyrolytic Graphite
HREM	High-resolution Electron Microscope (Microscopy)
IF	Inorganic Fullerenes
IMJs	Intramolecular Junctions
ITO	Indium Tin Oxide
MFP	Mean-free Path
MR	Magnetoresistance
MWNTs	Multi-wall Nanotubes
NR	Nanoribbons
NSP	Nebulized Spray Pyrolysis
NT-FETs	Nanotube Field-effect Transistors
NW	Nanowires (often prefixed by an elemental symbol, *e.g.* BiNW for Bismuth Nanowires)

PANI	Polyaniline
PDMS	Polydimethylsiloxane
PEG	Poly(ethylene glycol)
PEI	Polyethyleneimine
PFO	Poly(9,9-di-*n*-octylfluorenyl-2,7-diyl)
PL	Photoluminescence
PMMA	Poly(methyl methacrylate)
PPV	Poly(*p*-phenylene vinylene)
PVD	Physical Vapour Deposition
PVP	Poly(vinylpyrrolidone)
SAED	Selected-area Electron Diffraction
SDS	Sodium Dodecyl Sulphate
SEM	Scanning Electron Microscope (Microscopy)
SET	Single Electron Tunnelling
SFLS	Supercritical fluid–Liquid–Solid
SLS	Solution–Liquid–Solid
SHG	Second-harmonic Generation
sscm	Standard Cubic Centimetres per Minute
STM	Scanning Tunnelling Microscopy
STS	Scanning Tunnelling Spectroscopy
SWNTs	Single-wall Nanotubes
s-SWNTs	Shortened Single-wall Nanotubes
TB-DFT	Tight-binding Density Functional Theory
TEM	Transmission Electron Microscope (Microscopy)
TEP	Thermoelectric Power
THG	Third-harmonic Generation
VLS	Vapour-Liquid–Solid
VS	Vapour–Solid
XRD	X-ray Diffraction